Data Supplement - Web appendix for

"Recent trends in life expectancy across high-income countries"

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Table A1 | Sources of mortality and cause of death data*

A. All-cause mortality, 1990-2016			
Country	**HMD***	**Other National or International Database**	**Year**
Australia	1990-2014	Australian Bureau of Statistics	2015-2016
Austria	1990-2014	WHO	2015-2016
Belgium	1990-2015	Statistics Belgium	2016
Canada	1990-2011	Statistics Canada	2012-2015
Denmark	1990-2016		
Finland	1990-2015	Statistics Finland	2016
France	1990-2015	Institut national de la statistique et des études économiques (Insee)	2016
Germany	1990-2015	Statistics Germany	2016
Italy	1990-2014	Italian National Institute of Statistics	2015-2016
Japan	1990-2016		
Netherlands	1990-2014	Statistics Netherlands	2015-2016
Norway	1990-2014	Statistics Norway	2015-2016
Portugal	1990-2015	Statistics Portugal	2016
Spain	1990-2014	Instituto Nacional de Estadistica	2015-2016
Sweden	1990-2016		
Switzerland	1990-2014	Statistics Switzerland	2015-2016
United Kingdom‡	1990-2016		
United States	1990-2015	Centers for Disease Control and Prevention and National Center for Health Statistics	2016

B. Cause of death data, 2014-2015†	
Country	**Source**
Australia	WHO
Austria	WHO
Belgium	WHO
Canada	Statistics Canada
Denmark	WHO
Finland	WHO
Germany	WHO
Italy	WHO
Japan	WHO
Netherlands	WHO
Norway	WHO
Portugal	Statistics Portugal
Spain	WHO
Sweden	WHO
Switzerland	WHO
United Kingdom	WHO
United States	WHO

* HMD=Human Mortality Database

† WHO=World Health Organization Mortality Database

‡ The United Kingdom consists of England, Northern Ireland, Scotland, and Wales.

Table A2 | Cause of death categories and corresponding ICD-10 codes*			
Cause of death category	ICD-10 codes (WHO)	ICD-10 codes (Statistics Portugal)	Broad Category (Figures 4 and 5)
1. HIV/AIDS	B20–B24	B20–B24	Other Causes
2. Other infectious diseases	A00–B99, excluding B20–B24	-	Respiratory and Cardiovascular Diseases
3. Lung cancer	C33, C34	C33, C34	Other Causes
4. Breast, prostate, colorectal, and cervical cancer	C50, C53, C61, C18–C21	C50, C53, C61, C18–C21	Other Causes
5. All other cancers	C00–D48, excluding C33, C34, C50, C53, C61, C18–C21	C00–D48, excluding C33, C34, C50, C53, C61, C18–C21	Other Causes
6. Mental disorders	F01–F99	F01–F99	Nervous System and Mental Disorders
7. Nervous system, excluding Alzheimer's disease	G00–G98, excluding G30	G00-H95	Nervous System and Mental Disorders
8. Alzheimer's disease	G30	-	Nervous System and Mental Disorders
9. Circulatory diseases	I00–I99	I00-I99	Respiratory and Cardiovascular Diseases
10. Respiratory diseases, excluding influenza and pneumonia	J00–J98, excluding J09–J18	J00–J98, excluding J09–J18	Respiratory and Cardiovascular Diseases
11. Influenza and pneumonia	J09–J18	J09–J18	Respiratory and Cardiovascular Diseases
12. Diseases of the digestive system	K00–K92	K00–K92	Other Causes
13. Diabetes	E10–E14	E10–E14	Other Causes
14. Diseases of the genitourinary system	N00–N98	N00–N98	Other Causes
15. Perinatal conditions	P00–P96	P00–P96	Other Causes
16. Homicide	X86–Y09, Y87.1	X85–Y09	Drug Overdose and External Causes
17. Suicide	X60-X84, Y87.0, excluding X60-X64	X60-X84	Drug Overdose and External Causes
18. Drug overdose	X40–X44, X60-X64, X85, Y10–Y14	-	Drug Overdose and External Causes
19. Alcohol-induced	E24.4, F10, G31.2, G62.1, G72.1, I42.6, K29.2, K70, K85.2, K86.0, R78.0, X45, X65, and Y15	-	Drug Overdose and External Causes
20. Other external causes	V01–Y89, excluding X40-X44, X45, X60-X64, X65, X85–Y14,	V01–Y89, excluding X60-Y09	Drug Overdose and External Causes

	Y15, Y87.1		
21. Symptoms, signs, and ill-defined conditions	R00–R99	R00–R99	Residual
22. All other causes	Residual cause of death codes	Residual cause of death codes	Residual

*All codes included in the alcohol-induced category are excluded from the other cause of death categories. For all countries except Portugal, the homicide and suicide categories exclude drug-related homicides and suicides, which are included in the drug overdose category.

Table A3 | Change in life expectancy at birth (95% confidence intervals) between 2014 and 2015. Countries are ranked from largest decline to largest gain.		
A. Women		
Italy	-0.55	(-0.60 to -0.49)
Belgium	-0.36	(-0.50 to -0.22)
Germany	-0.36	(-0.41 to -0.30)
France	-0.29	(-0.35 to -0.23)
United Kingdom	-0.26	(-0.32 to -0.20)
Spain	-0.21	(-0.28 to -0.14)
Netherlands	-0.14	(-0.25 to -0.02)
United States	-0.13	(-0.16 to -0.09)
Austria	-0.10	(-0.26 to 0.06)
Portugal	-0.09	(-0.23 to 0.05)
Switzerland	-0.03	(-0.19 to 0.13)
Sweden	-0.03	(-0.17 to 0.12)
Denmark	0.02	(-0.18 to 0.22)
Canada	0.03	(-0.06 to 0.12)
Norway	0.05	(-0.16 to 0.26)
Australia	0.10	(0.00 to 0.21)
Japan	0.21	(0.17 to 0.25)
Finland	0.34	(0.15 to 0.53)
B. Men		
Italy	-0.43	(-0.50 to -0.37)
Germany	-0.30	(-0.36 to -0.25)
France	-0.25	(-0.32 to -0.18)
Austria	-0.22	(-0.39 to -0.04)
United Kingdom	-0.19	(-0.26 to -0.13)
Spain	-0.17	(-0.24 to -0.09)
United States	-0.17	(-0.20 to -0.13)
Netherlands	-0.08	(-0.20 to 0.04)
Switzerland	-0.08	(-0.26 to 0.10)
Sweden	-0.04	(-0.20 to 0.12)
Belgium	0.00	(-0.16 to 0.15)
Australia	0.01	(-0.11 to 0.12)
Portugal	0.10	(-0.07 to 0.26)
Canada	0.12	(0.03 to 0.22)
Denmark	0.20	(-0.01 to 0.41)
Japan	0.27	(0.22 to 0.31)
Norway	0.34	(0.11 to 0.56)
Finland	0.50	(0.28 to 0.71)

Table A4 | Change in life expectancy (years) between 2014 and 2015

A. Women	Between Ages 0-65	At Ages 65+
Australia	0.032	0.047
Austria	0.072	-0.246
Belgium	-0.022	-0.279
Canada	0.008	0.024
Denmark	0.013	-0.004
Finland	0.076	0.189
France	-0.005	-0.304
Germany	-0.037	-0.303
Italy	-0.048	-0.461
Japan	0.036	0.123
Netherlands	0.060	-0.219
Norway	0.016	-0.000
Portugal	0.025	-0.139
Spain	0.033	-0.253
Sweden	0.008	-0.075
Switzerland	0.031	-0.110
United Kingdom	0.013	-0.297
United States	-0.041	-0.066
B. Men	**Between Ages 0-65**	**At Ages 65+**
Australia	-0.037	0.085
Austria	-0.017	-0.251
Belgium	0.080	-0.102
Canada	-0.007	0.137
Denmark	0.116	-0.008
Finland	0.199	0.188
France	-0.042	-0.206
Germany	-0.027	-0.270
Italy	-0.093	-0.301
Japan	0.061	0.156
Netherlands	0.043	-0.169
Norway	0.109	0.144
Portugal	0.065	-0.028
Spain	0.024	-0.233
Sweden	-0.032	-0.007
Switzerland	0.005	-0.147
United Kingdom	-0.031	-0.154
United States	-0.094	-0.021

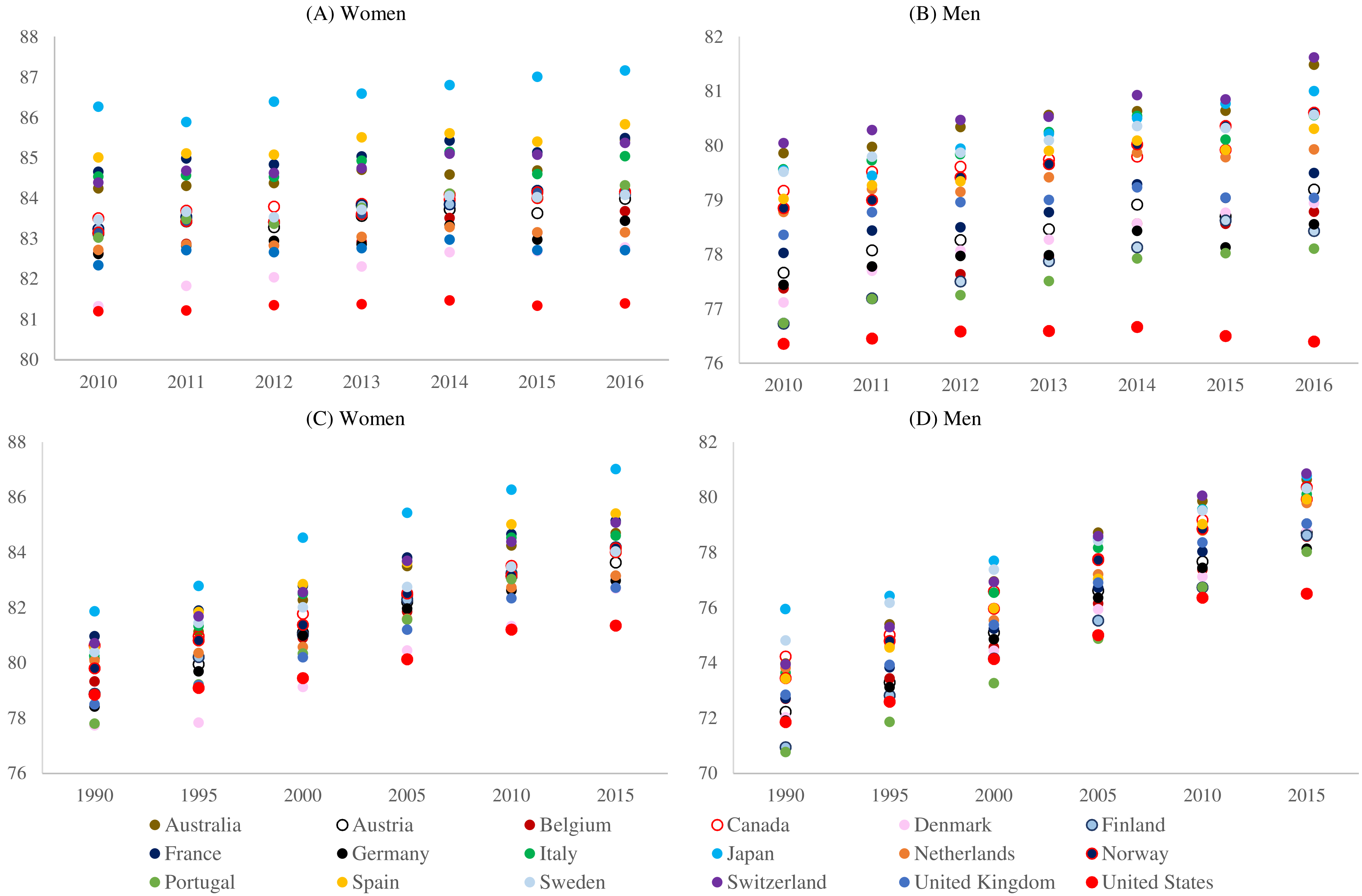

Fig A1 | Life expectancy at birth (years) in 18 high-income countries for (A) women, 2010-2016, (B) men, 2010-2016, (C) women, 1990-2015, and (D) men, 1990-2015. Each circle represents a country. Data for Canada are not available in 2016.

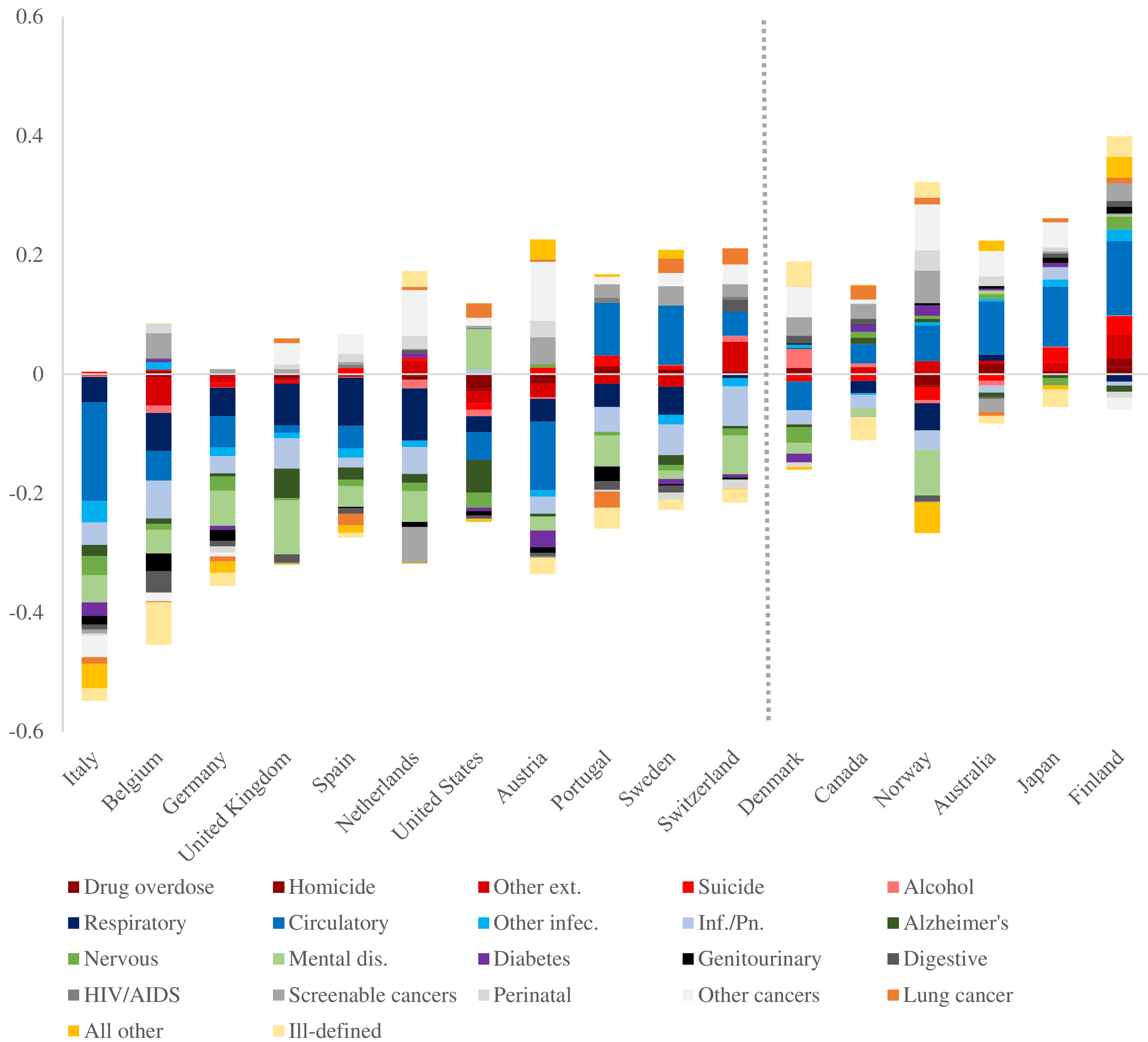

Fig A2 | Contribution of 22 cause of death categories to changes in life expectancy at birth between 2014 and 2015 for women in 17 high-income countries. Countries are ordered by the change in life expectancy at birth between 2014 and 2015, from largest decline to largest gain. Countries to the left of the dashed gray vertical line experienced a life expectancy decline between 2014 and 2015, and countries to the right of the dashed gray vertical line experienced a life expectancy gain between 2014 and 2015. Cause of death categories for Portugal differ slightly from those for the other countries (see table A2).

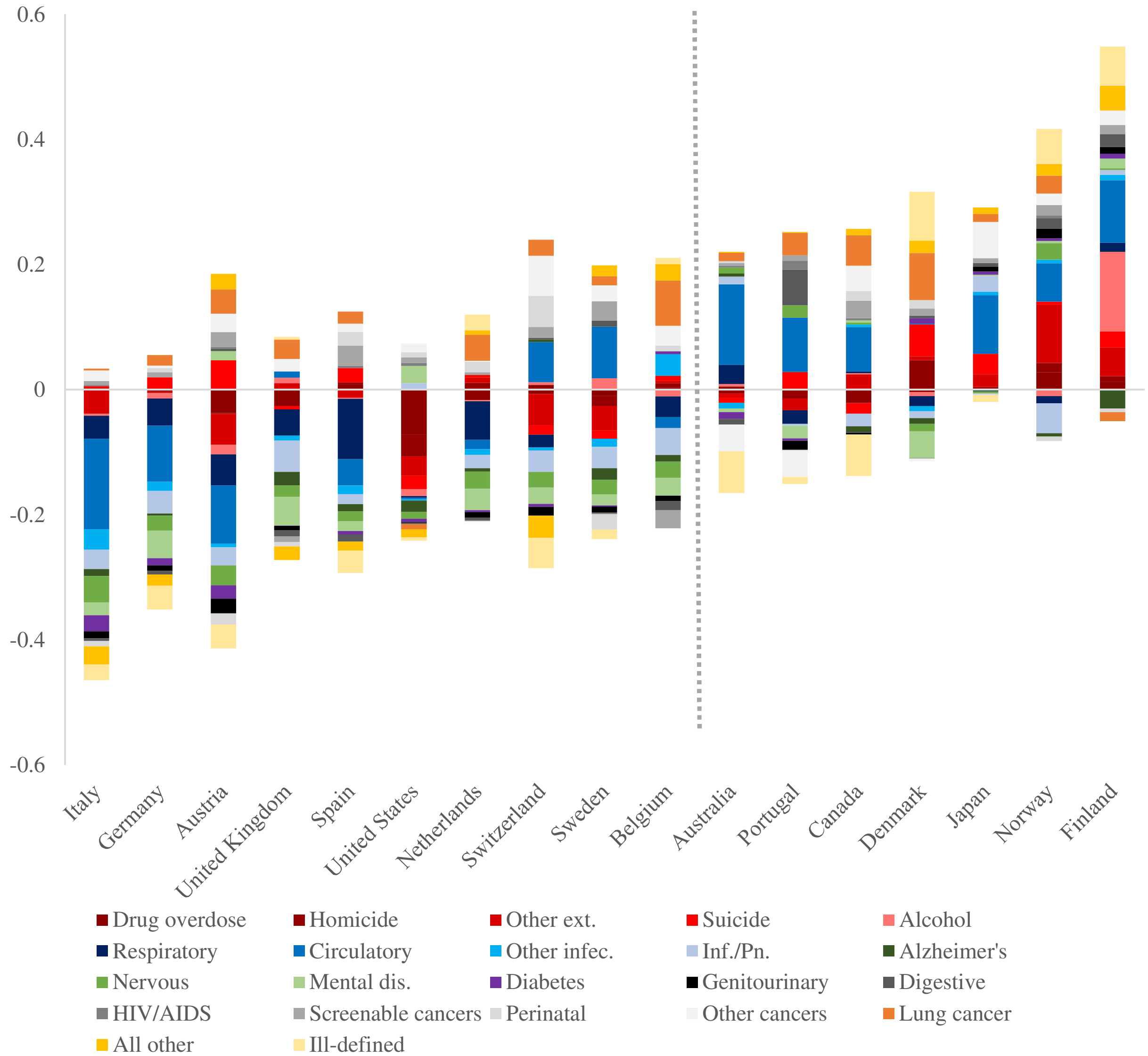

Fig A3 | Contribution of 22 cause of death categories to changes in life expectancy at birth between 2014 and 2015 for men in 17 high-income countries. Countries are ordered by the change in life expectancy at birth between 2014 and 2015, from largest decline to largest gain. Countries to the left of the dashed gray vertical line experienced a life expectancy decline between 2014 and 2015, and countries to the right of the dashed gray vertical line experienced a life expectancy gain between 2014 and 2015. Cause of death categories for Portugal differ slightly from those for the other countries (see table A2).

Data and Methodological Appendix

I. Data

The Human Mortality Database (HMD)[1] is the primary source of mortality data for these analyses. The HMD obtains raw death counts and population estimates from individual countries' national statistical offices. These data are then corrected for gross errors, and the population estimates are adjusted for age misreporting biases at older ages using extinct cohort methods. A key advantage is the fact that the HMD life tables are generated using a uniform set of procedures for each country. We use the death rates from the period life tables by single year of age for all countries through the latest year available from the HMD.

For several countries, more recent data are available through the national statistical offices than through the HMD (see table A1, panel A). We use these data to supplement the HMD data in order to maximize the representation of countries in our analysis. For these countries, we obtain deaths and population estimates in the most fine-grained age groups available. For sovereign states that contain multiple countries (e.g., the United Kingdom), the data are released as a combined data file (i.e., the data are not separate for England, Wales, Scotland, and Northern Ireland).

We employ the midyear or average annual population estimates. If population estimates are provided as of January 1, we adjust these estimates to the midyear assuming a constant annual growth rate. For example, if we have the population estimates as of January 1, 2015 and January 1, 2016 for a given age group, we obtain the population estimate as of July 1, 2015 as follows:

$$N(July\ 1, 2015) = N(Jan. 1, 2015) \times e^{\frac{\ln\left(\frac{N(Jan. 1, 2016)}{N(Jan\ 1., 2015)}\right)}{1} \times 0.5},$$

where N is the population estimate for that age group on the specified date.

The World Health Organization Mortality Database (WHO)[2] is the primary source of cause-specific mortality data for these analyses. The WHO contains data on deaths by age, sex, cause, and year for all medically-certified deaths from countries' civil registration systems. The WHO verifies that deaths are coded using official ICD-10 codes. The data were aggregated according to the major cause of death categories of interest.

For two countries (Canada and Portugal), the most recent cause-specific mortality data are available through the individual countries' vital statistics agencies[3,4] but not the WHO (see table A1, panel B). These data are downloaded directly from the vital statistics agencies' websites and, when possible, aggregated into the same cause of death categories used for the other countries (see table A2 for more detail).

II. Life tables

Life expectancy is a key summary measure of mortality conditions within populations and is calculated using life tables. Life tables can be calculated for periods (e.g., the population in the year 2016) or for cohorts (e.g., the population of individuals born in 1900). For period life tables, life expectancy at birth is interpreted as the number of years that a newborn who experiences the life table death rates throughout their lifetime can expect to live. For cohort life tables, life expectancy at birth is the average life expectancy (i.e., total number of years lived) by a member of that cohort. Calculating cohort life tables require that all members of that cohort have died out, thus, period life tables are commonly used to summarize the contemporary mortality experience of populations, although they do not correspond to the actual mortality experience of any real birth cohorts. In the subsequent sections, we focus on the case of period life tables.

In essence, we want to know for a given population, what is the number of people alive at each age, and how long do they live within a given age interval? Once these quantities are known for each age interval (e.g., 0-1, 1-2, … and so on), we can sum up all of these years of life (referred to as "person-years lived") to produce an estimate of the average number of years lived in the population. One of the key advantages of the life expectancy measure is that it is not sensitive to differences in age distributions across countries.

Age-specific death rates $({}_{n}m_{x})$ are the key inputs required to generate life tables. The units for death rates are deaths per person-years lived, where person-years are approximated using the midyear population. These death rates are converted to age-specific probabilities of dying $({}_{n}q_{x})$:

$$ {}_{n}q_{x} = \frac{n \times {}_{n}m_{x}}{1 + (n - {}_{n}a_{x}) \times {}_{n}m_{x}}, $$

where n is the length of the age interval, ${}_{n}m_{x}$ is the death rate between ages x and $x+n$, and ${}_{n}a_{x}$ is the average number of years lived by those who die between ages x and $x+n$.

For age groups 0 and 1-4, ${}_{n}a_{x}$ is derived using the Coale-Demeny (1983) West model life tables.[5] The lower mortality is at these ages, the more concentrated infant deaths become at younger ages, and these model life tables capture this regularity. For the following age group (either 5-6 or 5-9) and the penultimate age group, ${}_{n}a_{x}$ values of $n/2$ are used. For all of the intermediate age groups, a procedure called graduation is used to produce the ${}_{n}a_{x}$ values. This procedure uses information on the age distribution of deaths in the life table, assuming it follows a second degree polynomial function in the age interval $x-n$ to $x+2n$, such that:

$$ {}_{n}a_{x} = \frac{-\frac{n}{24}\,{}_{n}d_{x} + \frac{n}{2}\,{}_{n}d_{x} + \frac{n}{24}\,{}_{n}d_{x+n}}{{}_{n}d_{x}}, $$

where ${}_{n}d_{x}$ is the number of deaths between ages x and $x+n$. The initial ${}_{n}a_{x}$ values are set to $n/2$, and graduation is performed iteratively until stable estimates of the ${}_{n}a_{x}$ values are obtained (typically three to four iterations are sufficient).[5,6]

The number of individuals entering the life table at age 0 is called the radix and denoted as l_0. This can be set to any value; the most commonly used values are 1 and 100,000. The number of survivors at each age is calculated as:

$$l_{x+n} = l_x \times_n p_x = l_x(1 -_n q_x),$$

where $_np_x$ is the probability of surviving between ages x and $x+n$. In other words, the number of individuals surviving to the next age group is equal to the number of individuals alive at the start of the age interval multiplied by the probability of surviving the age interval (as defined above, $_nq_x$ is the probability of dying within the age interval so its inverse is the probability of surviving through the end of the age interval).

The number of deaths occurring in each age interval is:

$$_nd_x = l_x - l_{x+n} = l_x \times_n q_x.$$

Next, the person-years lived within each age interval $_nL_x$ is the sum of the person-years lived by those who survive through the end of the age interval and the sum of the person-years lived by those who die within that age interval:

$$_nL_x = n \times l_x +_n a_x \times_n d_x.$$

The total number of person-years lived above a given age x is:

$$T_X = \sum_{a=x}^{\infty} {}_nL_a.$$

Thus, life expectancy at any given age x is:

$$e_X = \frac{T_x}{l_x},$$

the total number of person-years lived above age x divided by the number of survivors to that age.

We use three key outcome measures derived from these life tables:

1) Life expectancy at birth (e_0^0), which is the number of years a newborn who experiences the life table death rates throughout their lifetime could expect to live:

$$e_0^0 = \frac{T_0}{l_0} = \frac{\int_0^{\infty} l(a)\mu(a)(a-x)\, da}{\int_0^{\infty} l(a)\mu(a)\, da},$$

where $l(a)$ is the number of survivors to age a and $\mu(a)$ is the force of mortality between ages a and $x+a$.

2) Life expectancy between ages 0-65 ($_{65}L_0$), which is the number of years a newborn who experiences the life table death rates throughout their lifetime could expect to live between the ages of 0 and 65. In a hypothetical population in which no deaths occurred between ages 0 and 65, the expected number of years lived between ages 0 and 65 would

be the full 65 years. In all of the populations considered here, deaths did occur between ages 0 and 65, so life expectancy between ages 0-65 ranged between 61.9-63.5 years among men and between 63.1-64.2 years among women in the 18 countries in 2015. Life expectancy between ages 0-65 is calculated as follows:

$$ {}_{65}L_0 = \frac{\sum_0^{65-n} {}_nL_x}{l_0} = \frac{\int_0^{65} l(a)\, da}{l_0}, $$

where $l(a)$ is as defined above and l_0 is the number of newborns entering the life table population (i.e., the radix). This quantity is also referred to as temporary life expectancy between ages 0-65.

3) Life expectancy at age 65, which is the number of years an individual who has survived to age 65 and who then experiences the life table death rates throughout the remainder of their lifetime could expect to live:

$$ e_{65} = \frac{T_{65}}{l_{65}} = \frac{\int_{65}^{\infty} l(a)\mu(a)(a-x)\, da}{\int_{65}^{\infty} l(a)\mu(a)\, da}, $$

where the quantities are as defined above.

The precise relationship that holds between these measures, assuming a radix of 1, is:

$$ e_0^0 = {}_{65}L_0 + l_{65} \times e_{65}, $$

where life expectancy at birth is equal to the sum of life expectancy between ages 0-65 and life expectancy at age 65 multiplied by the probability of surviving to age 65.

Confidence intervals for life expectancy declines

In all of our analyses, we use data on the total national populations for each country (i.e., a 100% sample). Nevertheless, we report 95% confidence intervals for our estimates of the change in life expectancy at birth between 2014 and 2015 in order to allow the interested observer to judge the uncertainty of the estimates and whether the differences between countries are statistically significant. We compute confidence intervals using a variation of the delta method approach described in Chiang (1984)[7]:

$$ Var(\widehat{e_0}) = \sum_{x=0}^{\infty} \left[\frac{l_x}{{}_np_x}(e_x - {}_na_x)\right]^2 \times \frac{{}_nq_x{}^2(1 - {}_nq_x)}{{}_nD_x}, $$

where ${}_nD_x$ is the number of actual deaths in the national population between ages x and $x + n$ in the corresponding calendar year. The 95% confidence interval is approximated as

$$ \widehat{e_0} \pm 1.96 \times Var(\widehat{e_0}). $$

We have provided a sample life table for Swedish males in 2015 below. Each of the columns described above are included in the table.

Table A5 | Life table for Swedish males, 2015. Source: Human Mortality Database (2018)[1]									
Year	**Age x**	$_nm_x$	$_nq_x$	$_na_x$	l_x	$_nd_x$	$_nL_x$	T_x	e_x
2015	0	0.00278	0.00278	0.14	100000	278	99762	8031917	80.32
2015	1	0.00017	0.00017	0.5	99722	17	99714	7932155	79.54
2015	2	0.00022	0.00022	0.5	99706	22	99695	7832441	78.56
2015	3	0.00007	0.00007	0.5	99684	7	99681	7732746	77.57
2015	4	0.00013	0.00013	0.5	99677	13	99671	7633066	76.58
2015	5	0.00005	0.00005	0.5	99664	5	99662	7533395	75.59
2015	6	0.00012	0.00012	0.5	99659	12	99654	7433733	74.59
2015	7	0.00007	0.00007	0.5	99648	7	99645	7334079	73.6
2015	8	0.00002	0.00002	0.5	99641	2	99640	7234435	72.6
2015	9	0.00003	0.00003	0.5	99639	3	99638	7134794	71.61
2015	10	0.00005	0.00005	0.5	99636	5	99633	7035157	70.61
2015	11	0.00007	0.00007	0.5	99631	7	99627	6935523	69.61
2015	12	0.00011	0.00011	0.5	99624	11	99618	6835896	68.62
2015	13	0.00009	0.00009	0.5	99613	9	99608	6736278	67.62
2015	14	0.00011	0.00011	0.5	99603	11	99598	6636670	66.63
2015	15	0.00013	0.00013	0.5	99592	13	99585	6537072	65.64
2015	16	0.00019	0.00019	0.5	99579	19	99569	6437486	64.65
2015	17	0.0003	0.0003	0.5	99560	30	99545	6337917	63.66
2015	18	0.00034	0.00034	0.5	99530	34	99513	6238372	62.68
2015	19	0.00057	0.00057	0.5	99496	57	99468	6138859	61.7
2015	20	0.00064	0.00064	0.5	99439	64	99407	6039392	60.73
2015	21	0.00061	0.00061	0.5	99376	60	99345	5939984	59.77
2015	22	0.00064	0.00064	0.5	99315	64	99283	5840639	58.81
2015	23	0.00061	0.00061	0.5	99251	61	99221	5741356	57.85
2015	24	0.00083	0.00083	0.5	99191	83	99149	5642135	56.88
2015	25	0.00089	0.00089	0.5	99108	88	99064	5542985	55.93
2015	26	0.00083	0.00083	0.5	99020	82	98979	5443921	54.98
2015	27	0.00079	0.00079	0.5	98938	79	98899	5344942	54.02
2015	28	0.00076	0.00076	0.5	98859	75	98822	5246044	53.07
2015	29	0.00073	0.00073	0.5	98785	72	98749	5147222	52.11
2015	30	0.00073	0.00073	0.5	98713	72	98677	5048473	51.14
2015	31	0.00054	0.00054	0.5	98641	53	98615	4949796	50.18
2015	32	0.0007	0.0007	0.5	98588	69	98553	4851181	49.21
2015	33	0.00096	0.00096	0.5	98519	95	98471	4752628	48.24
2015	34	0.00064	0.00064	0.5	98424	63	98392	4654157	47.29
2015	35	0.00093	0.00093	0.5	98361	92	98315	4555764	46.32
2015	36	0.00086	0.00086	0.5	98269	85	98227	4457449	45.36
2015	37	0.00089	0.00089	0.5	98184	88	98140	4359223	44.4
2015	38	0.00065	0.00065	0.5	98097	64	98065	4261082	43.44
2015	39	0.00081	0.00081	0.5	98033	80	97993	4163017	42.47
2015	40	0.00102	0.00102	0.5	97953	100	97903	4065024	41.5

2015	41	0.00098	0.00098	0.5	97854	96	97806	3967121	40.54
2015	42	0.00113	0.00113	0.5	97758	110	97703	3869315	39.58
2015	43	0.00108	0.00108	0.5	97647	106	97595	3771613	38.62
2015	44	0.00111	0.00111	0.5	97542	108	97488	3674018	37.67
2015	45	0.00125	0.00125	0.5	97434	122	97373	3576530	36.71
2015	46	0.00124	0.00124	0.5	97312	121	97252	3479157	35.75
2015	47	0.00176	0.00176	0.5	97191	171	97105	3381905	34.8
2015	48	0.00174	0.00174	0.5	97020	169	96935	3284800	33.86
2015	49	0.0021	0.00209	0.5	96851	203	96749	3187865	32.92
2015	50	0.00224	0.00224	0.5	96648	217	96540	3091115	31.98
2015	51	0.00227	0.00227	0.5	96431	219	96322	2994576	31.05
2015	52	0.00314	0.00313	0.5	96213	301	96062	2898254	30.12
2015	53	0.0034	0.00339	0.5	95911	325	95749	2802192	29.22
2015	54	0.00377	0.00377	0.5	95586	360	95406	2706443	28.31
2015	55	0.00403	0.00402	0.5	95226	383	95034	2611037	27.42
2015	56	0.00433	0.00432	0.5	94843	410	94638	2516003	26.53
2015	57	0.00486	0.00485	0.5	94433	458	94204	2421364	25.64
2015	58	0.0055	0.00548	0.5	93975	515	93717	2327160	24.76
2015	59	0.00572	0.0057	0.5	93460	533	93193	2233443	23.9
2015	60	0.00656	0.00654	0.5	92926	608	92623	2140250	23.03
2015	61	0.00673	0.00671	0.5	92319	619	92009	2047627	22.18
2015	62	0.00779	0.00776	0.5	91699	711	91344	1955618	21.33
2015	63	0.00883	0.00879	0.5	90988	799	90588	1864275	20.49
2015	64	0.00974	0.00969	0.5	90189	874	89752	1773686	19.67
2015	65	0.01073	0.01067	0.5	89315	953	88838	1683935	18.85
2015	66	0.01236	0.01229	0.5	88362	1086	87819	1595096	18.05
2015	67	0.01286	0.01278	0.5	87276	1115	86718	1507278	17.27
2015	68	0.01373	0.01363	0.5	86161	1175	85573	1420559	16.49
2015	69	0.01524	0.01513	0.5	84986	1285	84343	1334986	15.71
2015	70	0.01695	0.01681	0.5	83701	1407	82997	1250643	14.94
2015	71	0.0209	0.02068	0.5	82294	1702	81442	1167646	14.19
2015	72	0.02119	0.02097	0.5	80591	1690	79746	1086203	13.48
2015	73	0.02317	0.0229	0.5	78901	1807	77998	1006457	12.76
2015	74	0.02773	0.02735	0.5	77094	2108	76040	928459	12.04
2015	75	0.03055	0.03009	0.5	74986	2257	73858	852419	11.37
2015	76	0.03188	0.03138	0.5	72729	2283	71588	778561	10.7
2015	77	0.03651	0.03586	0.5	70447	2526	69184	706973	10.04
2015	78	0.04416	0.0432	0.5	67921	2934	66454	637789	9.39
2015	79	0.04748	0.04638	0.5	64986	3014	63480	571336	8.79
2015	80	0.05741	0.05581	0.5	61973	3459	60243	507856	8.19
2015	81	0.0607	0.05892	0.5	58514	3447	56790	447613	7.65
2015	82	0.06926	0.06694	0.5	55067	3686	53223	390822	7.1
2015	83	0.07882	0.07583	0.5	51380	3896	49432	337599	6.57

2015	84	0.0903	0.0864	0.5	47484	4103	45433	288167	6.07
2015	85	0.10912	0.10348	0.5	43382	4489	41137	242733	5.6
2015	86	0.1204	0.11357	0.5	38893	4417	36684	201596	5.18
2015	87	0.13604	0.12737	0.5	34476	4391	32280	164912	4.78
2015	88	0.15304	0.14216	0.5	30085	4277	27946	132632	4.41
2015	89	0.17881	0.16413	0.5	25808	4236	23690	104685	4.06
2015	90	0.19027	0.17374	0.5	21572	3748	19698	80996	3.75
2015	91	0.22321	0.2008	0.5	17824	3579	16034	61298	3.44
2015	92	0.25352	0.225	0.5	14245	3205	12642	45264	3.18
2015	93	0.2767	0.24307	0.5	11040	2683	9698	32621	2.95
2015	94	0.2968	0.25844	0.5	8356	2160	7277	22923	2.74
2015	95	0.33721	0.28856	0.5	6197	1788	5303	15647	2.52
2015	96	0.37057	0.31264	0.5	4409	1378	3719	10344	2.35
2015	97	0.40521	0.33694	0.5	3030	1021	2520	6625	2.19
2015	98	0.44082	0.36121	0.5	2009	726	1646	4105	2.04
2015	99	0.47706	0.38518	0.5	1283	494	1036	2458	1.92
2015	100	0.51353	0.40861	0.5	789	322	628	1422	1.8
2015	101	0.54986	0.43129	0.5	467	201	366	794	1.7
2015	102	0.58567	0.45301	0.5	265	120	205	428	1.61
2015	103	0.62059	0.47363	0.5	145	69	111	223	1.54
2015	104	0.65431	0.49302	0.5	76	38	58	112	1.47
2015	105	0.68655	0.5111	0.5	39	20	29	54	1.41
2015	106	0.71708	0.52783	0.5	19	10	14	26	1.35
2015	107	0.74573	0.54319	0.5	9	5	7	12	1.31
2015	108	0.77241	0.55721	0.5	4	2	3	5	1.27
2015	109	0.79705	0.56992	0.5	2	1	1	2	1.24
2015	110+	0.81964	1	1.22	1	1	1	1	1.22

III. Cause of death decomposition

Cause of death decomposition is a method that apportions differences in life expectancies to differences in cause-specific death rates. In this paper, the differences in life expectancy in 2015 and 2014 for each country are decomposed into differences in 22 mutually exclusive and exhaustive causes of death (see table A2).

First, the contribution of all-cause mortality differences in age group x to $x+n$ to the difference in life expectancy at birth is:

$$_n\Delta_x = \frac{l_x^{2014}}{l_0^{2014}}\left(\frac{{}_nL_x^{2015}}{l_x^{2015}} - \frac{{}_nL_x^{2014}}{l_x^{2014}}\right) + \frac{T_{x+n}^{2015}}{l_0^{2014}}\left(\frac{l_x^{2014}}{l_x^{2015}} - \frac{l_{x+n}^{2014}}{l_{x+n}^{2015}}\right).$$

The first term of this equation captures the effect of a change in the number of years lived between ages x and $x+n$ on life expectancy at birth (the direct effect). The second term of this equation captures the effect of added person-years coming from additional survivors to age $x+n$ (indirect and interaction effects).[5,8]

Across all ages, these contributions sum to the difference in life expectancy at birth:

$$\sum_0^{\infty} {}_n\Delta_x = e_0^0(2015) - e_0^0(2014).$$

Next, the contribution of differences in each cause-specific death rate within each age interval is calculated as:

$${}_n\Delta_x^i = \frac{\frac{{}_nD_x^i(2015)}{{}_nD_x(2015)} \times {}_nm_x(2015) - \frac{{}_nD_x^i(2014)}{{}_nD_x(2014)} \times {}_nm_x(2014)}{{}_nm_x(2015) - {}_nm_x(2014)},$$

where ${}_nD_x^i(y)$ is the number of deaths from cause i in year y, ${}_nD_x(y)$ is the total number of deaths in year y, and ${}_nm_x(y)$ is the all-cause death rate in year y. This approach, known as Arriaga's decomposition, assumes that the distribution of deaths by cause is constant within each age group in the population, which allows the differences in all-cause mortality in a specific age group to be distributed proportionately to differences in cause-specific mortality in that age group.[9] Thus, within each age group, these cause-specific contributions sum up to ${}_n\Delta_x$. In total, these cause-specific contributions sum up to the total difference in life expectancy at birth between in 2015 and 2014. In other words,

$${}_n\Delta_x = \sum_i {}_n\Delta_x^i$$

and

$$\sum_x \sum_i {}_n\Delta_x^i = \sum_0^{\infty} {}_n\Delta_x = e_0^0(2015) - e_0^0(2014).$$

IV. Cause-deleted life tables

Cause-deleted life tables are used to estimate what life expectancy would be in the absence of a particular cause of death i. This requires us to make an assumption about what mortality would look like in the absence of that particular cause of death.

The standard approach is to use Chiang's assumption, which assumes that the force of mortality from cause i is proportional to the force of mortality from all causes combined in each age interval.[5,10] In other words, we assume that in the absence of cause i, the shape of the mortality curve within a given age interval x to $x + n$ is identical to the observed case, and it is only the level of mortality that is getting shifted downwards within that age interval. This assumption operates best when the curvature of mortality is not very steep, which holds for most of the age range.

A new life table is generated during this procedure—the cause-deleted life table—and its columns are denoted using the asterisk * to differentiate these columns from the observed life table columns described in section I.

First, the probability of surviving between ages x to $x + n$ in the absence of cause i is:

$${}_n^*p_x^{-i} = {}_np_x^{\frac{{}_nD_x - {}_nD_x^i}{{}_nD_x}},$$

where the quantities are as defined in the above sections.

A new column of survivors to each age in the absence of cause i is calculated as:

$$^{*}l_{x+n}^{-i} = {}^{*}l_{x}^{-i} \times {}_{n}^{*}p_{x}^{-i}.$$

To derive the ${}_{n}^{*}a_{x}^{-i}$ values, a combination of graduation and interpolation is used (see Preston et al. 2001 for further detail). The remainder of the life table columns are calculated using the standard formulas, and the final outcome quantity of interest is the life expectancy column, ${}^{*}e_{x}^{-i}$, which specifies what life expectancy would be at each age in the absence of cause i.

With regards to the assumption used to generate cause-deleted life tables, the issue is whether mortality in the counterfactual scenario—the absence of a specific cause of death—is correctly specified. Since this counterfactual scenario is never observed in reality, it is fundamentally unidentifiable.[11,12] This is also known as the competing risks problem. All individuals in a population must eventually die and be assigned a specific cause of death. If deaths from a particular cause are removed, individuals who died of that cause may be subject to the risks of dying from all other causes differentially compared to individuals who did not die of that cause. We address this issue in two ways: first, by using broad cause of death categories which group together correlated risks and renders the results less sensitive to the competing risks problem, and second, by ensuring that the results are robust by computing cause-deleted life tables using an alternative assumption that the force of mortality is constant in the age interval. Using this approach,

$${}_{n}^{*}p_{x}^{-i} = e^{-n \times {}_{n}M_{x}^{-i}},$$

$${}_{n}^{*}L_{x}^{-i} = \frac{{}^{*}l_{x}^{-i} - {}^{*}l_{x+n}^{-i}}{{}_{n}M_{x}^{-i}},$$

and the remainder of the life table is completed using standard methods. n is the length of the age interval and ${}_{n}M_{x}^{-i}$ is the death rate from causes other than i. We find that results using this approach are essentially identical to those presented in Table 2 of the main paper (available upon request from the authors).

V. References for the Data and Methodological Appendix

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